

Remarks

Claims 1-14 are pending and stand rejected under 35 U.S.C. §103 as being obvious from the teachings of various prior art references. Claim 13 has been amended to correct a minor problem in dependency.

Claim 1

Claim 1 is directed to "cone beam CT scanning in which respiration correlation techniques are applied to the acquired two-dimensional projection images." In other words, to imaging that takes into account the respiratory cycle. The rejections of claim 1 rely on either Edic and/or Bulkes (in combination with various other references).

Specifically, claim 1 is rejected based on Bulkes in view of Edic and Rasche, and also by Rasche in view of Edic. Bulkes uses an external ECG apparatus and mechanical motion sensors to detect cardiovascular phase. It also contemplates measuring changes in pressure, sound, or blood flow acceleration. This is used to gate the output of a third-generation CT scanner, one that is described as a "four slice CT system." It is noted that the system may, alternatively, be a single-slice or other multi-slice configuration. This makes absolutely clear that the system is not a cone-beam CT system (as the Examiner recognizes at the bottom of page 2). It cannot therefore select two dimensional images based on their phase because there will be no such two dimensional images.

The question therefore has to be asked, what would be done to the Bulkes arrangement if it were extended to a cone-beam CT system. The answer is helpfully provided by the Examiner - Edic has a detailed disclosure of another "slice" CT system but suggests extending this to cone beam CT and develops a method that can cope with the increased complexity thereof. It selects

"radiographs" for use in reconstruction based on their position in the cardiovascular cycle. As defined at column 4 lines 26 to 50, a single "radiograph" (or "view") is the data obtained from one particular orientation of the gantry. Care is taken (column 5 lines 1 to 7) to ensure that the rotational period is out of phase with the cardiac cycle, thereby ensuring that each "view" consists of a plurality (one per revolution) of images at different points in the cardiac cycle. Edic also discloses measurement of the phase of the heart by the use of an ECG or a stethoscope (column 5, line 10 clearly describes an external sensor) and labels each image with the cardiac phase information thus obtained.

Edic thus obtains a large dataset consisting of views from each possible gantry position, each view consisting of a number of images all at different points in the cycle. Edic then uses each image of the view and the information as to its phase to create an interpolated image at a specific point in the cardiac cycle. This is repeated for each view and these interpolated images, one per view, are then used to reconstruct a radiograph of the heart at the chosen point in its cycle.

At the paragraph at the top of page 3 of the Office action, the examiner asserts that "The method [of the present invention] selects what projection images are to be reconstructed, not how to reconstruct them". This is indeed the case, but what the examiner has missed is that Edic and Bulkes select different images for reconstruction. As will be apparent from the above, Edic does not even use the images for reconstruction. Instead, Edic computes up to 1,000 interpolated images and then uses these. Claim 1, on the other hand, specifies that respiration correlation techniques are applied to the acquired two-dimensional projection images, i.e. suitable images from the acquired set are chosen prior to reconstruction. This then allows a reconstruction to be

based on images that are of like phase, as opposed to the small variation in phase that will have taken place during the acquisition of data contributing to a single slice.

So by referring to "what projection images are to be reconstructed, not how to reconstruct them", the Examiner misses the fact that the cited documents do not select from the projection images for reconstruction at all. Reconstruction in Edic is based on the interpolated (and hence fictional) images, contrary to that claimed in the present application. Edic must do so since the frame rate is similar to the cardiac cycle being measured, so the chances of the successive images being close enough in phase is too low. For the respiratory cycle, we have found that the images can be selected on the basis of their phase and that there will be sufficient numbers of images that are close enough in phase to allow reconstruction. Given the different nature of the cardiac cycle and the different solution adopted by Edic, there is no teaching of this point by Edic and there can be no suggestion that the claimed solution be adopted.

Furthermore, the Examiner concedes with respect to Bulkes that it does not teach respiration correlation techniques as required by claim 1, but rather is directed to cardiac imaging. The Examiner postulates that one of ordinary skill "would readily recognize that the method of Bulkes is equally applicable to correlating either or both cyclic physiological phenomena. Applicant respectfully disagrees.

There are at least two differences between cardiac and respiratory imaging systems that lead to distinctions that are significant for our purposes. First, cardiac imaging inevitably involves a smaller and faster moving image which makes it less feasible to determine phase on the basis of a feature in the projection image. Unsurprisingly therefore, Bulkes (and Edic which is also a cardiac imaging system) use external monitors rather than features of the projection

image. Second, the time period involved in the cardiac cycle is very much smaller, and is similar to the "frame rate" of the imaging system. This means that while the problem may be essentially similar, the solution adopted by Bulkes (and Edic) is significantly different.

The examiner refers to Rasche, pointing out that it discloses use of the diaphragm position to identify respiration phase, but Rasche does not use the diaphragm position in an image to do so. Rasche merely uses an abdominal belt which he says gives secondary information as to the diaphragm position. Rasche does not use a feature in the projected image; Rasche uses external sensors. It seems to suggest that the patients hold their breath on the basis of the respiratory monitor, and that the data is tagged according to the ECG monitor.

Thus, no combination of Bulkes, Edic, and/or Rasche teaches or suggests "cone beam CT scanning in which respiration correlation techniques are applied to the acquired two-dimensional projection images" as is required by claim 1.

Claim 1 also stands rejected under the theory that that it is obvious to modify Kanematsu by using the cone beam CT methods of Edic. As an initial matter, Edic uses a different method of reconstruction as already explained above. As already explained, Edic's CBCT suggestions on their own do not take the skilled person to the invention of claim 1, and adding to them the slice CT of Kanematsu does not change that case. So even if the skilled person were to make the combination, they do not reach the invention.

Moreover, the cited passages in Kanematsu do not describe the production of a high quality CT image that includes respiration correlation. The passage at column 11 speaks of adjusting the patient support (bed) in a cyclical manner so as to compensate for the cyclical movement of the patient's organs due to respiration. Thus, a therapeutic beam will cause less

side-effects. This is not in any sense a disclosure of a respiration-correlated imaging system - nothing is done with the images because none are being collected at this point. Thus, the combination of Kanematsu and Edic also fails to teach or suggest the system of claim 1.

Since as explained above, no combination of the prior art teaches or suggests a system as in claim 1, it should be allowed. Claims 2-7 depend from claim 1 and are allowable for the same reasons. Independent claims 8 and 14 are like claim 1 in using "respiration correlation techniques" as applied to "acquired two-dimensional projection images" and are therefore allowable for the same reasons as claim 1. Claims 9-13 depend from claim 8 and are allowable for the same reasons. Reconsideration and issuance of a Notice of Allowance are respectfully requested.

Claim 4

In addition to all of the foregoing, Applicant points out that claim 4 is directed to a system as in claim 1 which further monitors the phase of the patient's breathing continuously during acquisition of projection images and uses a feature in the projection image(s) to determine the breathing phase. Claim 4 is rejected on the basis of either (1) Bulkes, Edic and Rasche, or (2) Rasche and Edic, (as discussed above) in further view of Hsieh.

The Examiner notes that "neither Bulkes nor Edic nor Rasche specifically disclose that the breathing phase is determined by a feature in the projection image." This suggests that they leave the question open, in which case it would be appropriate to look elsewhere for details as to how to do so. In fact, they disclose the precise opposite; they disclose the use of external monitors.

We can dismiss Bulkes immediately since the one-dimensional images obtained by the slice CT system of Bulkes will not contain adequate information to identify a feature that could be used in this way. Not only does Bulkes fail to disclose or suggest this feature, it is therefore impossible for the system of Bulkes to have done so.

Turning to Hsieh, this discloses a cardiac motion correlator for CT systems, but seems to do so in a different manner. As an initial matter, Applicant points out that in being directed to cardiac imaging, Hsieh differs from the claimed respiratory imaging system for the reasons already given above for Bulkes and Edic. In addition, claim 4 specifies that "a feature in the projection image(s) is used to determine the breathing phase," but Hsieh looks to pairs of images and minimizes an "inconsistency index" derived via a differential image.

Hsieh uses the projection data directly, and is concerned with identifying regions of the acquisition space (as a function of the angle of the CT gantry) for which the projection data is most consistent between the start and end of the region. These regions can either be a full scan (360 degrees) or a half scan (180 degrees plus maximum detector angle), and the theory as stated in column 3 line 53 will therefore produce a reconstructed image with minimal motion artifacts.

Hsieh always uses a contiguous set of projections to form the reconstruction. The purpose of his invention is to select the 'reconstruction location' for the least artifacts. This is defined as being the one with the most consistent start and end projection. This location is not a physical location as such, but a region within the set of all projection data.

Moreover, his idea of a differential projection is the difference between the start of the region he is going to use to reconstruct and the end of the region. If the case of a full scan (360 degrees of projection data used) he is looking at the difference between the data at one angle and

the data 360 degrees further on. He then evaluates this difference (or differential projection) for all possible starting angles. In contrast, in the invention of claim 4, we are looking at each image independently. We may later look at forming a differential of consecutive images in order to extract the phase of the breathing cycle, but at no time do we form the differential projection data between the start and end of a region as described.

Hsieh analyzes the data along the line of the CT detector, i.e. in the reconstruction plane and across the patient. This is because he is looking to form a consistent reconstruction. In claim 4, we are primarily analyzing the image along the axis of rotation, e.g. the diaphragm moving up and down. In essence, there is a difference of approach; Hsieh is looking at the problem in a CT way, claim 4 attacks the problem in a fluoroscopy way.

In short, the difference is that Hsieh is looking for a sequence of images in which the difference is minimized. That will always draw him towards the extremities of the cycle - equivalent to the top dead center and the bottom dead center of a rotational cycle. The solution of claim 4 is to look for a feature in the image that discloses its phase, and select images with like phase. Claim 4 may therefore obtain a group of discontinuous images, whereas Hsieh must always obtain a sequence of adjacent images. Claim 4 can choose any point in the cycle, whereas Hsieh's system chooses for itself and will (in practice) always go to one of the two extremities. Hsieh is not looking for a feature in the image; he is looking for a much more generic differential function. So, at first glance Hsieh looks relevant, but on detailed examination the technique is quite different.

Thus, there are several flaws in the examiner's argument. He asserts that Bulkes, Edic and Rasche need some means of detecting the breathing phase, whereas they all disclose an

actual means of doing so that is directly contrary to claim 4. There is therefore no requirement to look to Hsieh or elsewhere to obtain such a means. Further, he asserts that Hsieh shows the use of a feature in the projection image to determine breathing phase, whereas this is not the case. Hsieh evaluates a difference image between time-spaced images at the start and end of a selected period to determine a time period (and hence a group of images) that are in the same phase. Hsieh does not therefore provide the means claimed in claim 4.

So, to summarize, Bulkes, Edic and Rasche do not need help from Hsieh, but if they do call upon such help then Hsieh does not give them the claimed solution.

This difference is significant. Hsieh's method can, at best, yield a subset of images that are sequential. Hsieh's method relies on the speed of acquisition of images being such that sufficient images are acquired within a portion of one cycle to yield a satisfactory reconstruction. This is not a restriction of the implied by the present invention. It is a restriction that will limit the applicability of Hsieh.

If the cycle is ongoing, this will limit the number of available images and reduce the quality of the reconstruction. Images that are at the same phase of the breathing cycle but in a later cycle will not be available. The result therefore is that the patient must hold their breath for an extended period, or the image quality will suffer. The approach claimed in the present application allows for a high quality reconstruction while the patient continues breathing. That is because we are using the breathing cycle for selection of images. Hsieh refers to holding the breath to avoid the two independent motions of breathing and the heart confusing the image. The reconstructed image of the heart is improved by ensuring that it is not only all from a set of

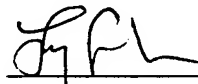
sequential images during which the heart motion is minimal but also that the motion due to breathing is also minimal.

Claim 11 is like claim 4 and allowable for the same reasons. Reconsideration and issuance of a Notice of Allowance are respectfully requested.

Conclusion

Applicant hereby requests a one month extension of time in accordance with the provisions of 37 C.F.R. § 1.136. Please charge deposit account 19-4972 for the amount of \$120.00 for the fee for the one month extension of time. Applicant believes that no further extension of time is required; however, this conditional petition is being made to provide for the possibility that the applicant has inadvertently overlooked the need for a further additional extension of time. If any additional fees are required for the timely consideration of the application, please charge deposit account number 19-4972.

Respectfully submitted,



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